EX PARTE OR LATE FILED

DOCKET FILE COPY ORIGINAL

ORIGINAL

COMSAT
International Communications

Nancy J. Thompson
General Attorney

6560 Rock Spring Drive
Bethesda, Maryland 20817
Telephone 301 214 3473
Fax 301 214 7145
Telex 197800

April 30, 1996

BY HAND

RECEIVED

APR 30 1996

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

Re: Ex Parte Contact in ET Docket No. 95-18

Dear Mr. Caton:

On Thursday April 25, 1996, COMSAT Corporation ("COMSAT") hosted a meeting for representatives of the Mobile Satellite Service ("MSS") industry and representatives of the terrestrial Fixed Service ("FS") industry which related to issues under consideration in the above-referenced proceeding. The parties representing COMSAT were John S. Hannon, Raymond Crowell, Jeffrey Binckes, Sam Nguyen, David Weinreich, Peter Chang, Dan Swearingen and the undersigned. FCC staff from the Office of Engineering & Technology and the International Bureau were also in attendance. The primary purpose of the meeting was to discuss the potential for sharing between the terrestrial FS microwave facilities and MSS systems operating in the MSS downlink band at 2165-2200 MHz and to demonstrate commercially available simulation software which can be used as a tool in assessing the levels of interference into FS systems from MSS system operation. A copy of the materials distributed to the meeting attendees is attached to the original and one copy of this letter filed with the Secretary.

Respectfully submitted,

Nancy J. Thompson

Nancy J. Thompson

Attachments

cc: Sean White
Steve Sharkey
Alex Latker
Damon Ladson

No. of Copies rec'd 0+1
List ABCDE

MSS & FS Industry Meeting Related to FCC ET Docket No. 95-18
COMSAT Corporation, Bethesda, Maryland
April 25 & 26, 1996

1. Welcome and Opening Remarks

    a. purpose of the meeting
    b. relationship of industry discussions to FCC Rulemaking
    c. select chairman for this meeting

2. Approval of Agenda

    a. overview of agenda and method of work during the meeting
    b. administrative items

3. FCC 2 GHz Rulemaking in ET Docket No. 95-18 and MSS / FS Sharing Issues

    a. update and status of the Rulemaking
        - presentation and discussion
    b. WRC-95 results and relationship to Rulemaking
        - presentation and discussion
    c. benefits of industry discussions on the sharing issue in the band 2165 - 2200 MHz
        - discussion
    d. review and status of ITU-R studies and relationship to Rulemaking
        - presentation and discussion

4. New Simulation Software for Interference Analysis

    a. description of Simulation Software
        - presentation and discussion
    b. demonstration of Simulation Software
        - discussion

5. Issues to be Addressed and Information to be Exchanged

    a. system performance objectives for fixed service operations
        - ITU-R studies and recommendations
        - U.S. system operators

    b. interference Criteria
        - ITU-R studies and recommendations
        - U.S. system operators

6. Perform Interference Assessment Examples
   [for demonstration and discussion purposes only]

   a. use new simulation software
   b. use representative cases for MSS and FS systems
   c. discuss results and method

7. How to Proceed Now and During the Next Several Months

   a. agree on necessary working assumptions
      - performance objectives for FS systems
      - interference criteria for FS systems
      - satellite system characteristics
      - other

   b. agree on methodology to be used for interference assessments

   c. case studies to be performed
      - representative cases
      - assumed worst cases
      - randomly selected cases

   d. create Technical Working Group (TWG) to perform case studies
      - TWG works by correspondence and in ad hoc meetings
      - name TWG Coordinator and Members
      - TWG reports results to full group

   e. proposed schedule to conduct work and report results
      - by ________, exchange information among TWG for case studies
      - by ________, run case studies
      - by ________, distribute results to TWG
      - ________, TWG meets to discuss case studies and determine future work
      - full group meets on date _______ to discuss TWG results and future work

8. Other Business

9. Adjourn

REVIEW STATUS OF ITU-R STUDIES & RECOMMENDATIONS RELATED TO MSS/FS SHARING

- WRC -95 Final Acts, re 2 GHz MSS bands, are based on the conclusion that MSS and FS can share the 2 GHz downlink band over an extended period of time
- Dates of Entry into Force for 2 GHz MSS have been advanced to 2000 from previous (WARC-92) date 2005
- Studies on MSS/FS sharing show that internationally agreed performance objectives for existing FS systems can (still) be met, taking into account added interference noise from MSS satellite downlinks as documented by :

  1) ITU-R Task Group 2/2 in ITU-R Doc. 2-2/TEMP/94(Rev.1)-E

  2) Conference Preparatory Meeting for WRC-5 in "WRC-95 CPM Report"

REVIEW STATUS OF ITU-R STUDIES & RECOMMENDATIONS RELATED TO MSS/FS SHARING

- The 1995 Radiocommunication Assembly approved 3 Recommendations (ITU-R IS. 1141, IS.1142 and IS.1143) dealing with MSS/FS frequency sharing:

  1) Rec. ITU-R IS.1141 - "Sharing in the frequency bands in the 1-3 GHz frequency range between the non-geostationary space stations operating in the MSS and the FS"

  2) Rec. ITU-R IS.1142 - "Sharing in the frequency bands in the 1-3 GHz frequency range between the geostationary space stations operating in the MSS and the FS"

  3) Rec. ITU-R IS.1143 - "System specific methodology for coordination of non-geostationary space stations (space-to-Earth) operating in the MSS with the FS receive stations"

- WRC-95 adopted the following Resolutions and Recommendations related to MSS/FS sharing:

  Resolution 716 (COM5-10) - "Use of frequency bands 1980-2010 MHz and 2170-2200 MHz in all three regions and 2010-2025 MHz and 2160-2170 MHz in Region 2 by the FS and MSS and associated transition arrangements"

  Resolution 46 (Rev. WRC-95) - "Interim procedures for the coordination and notification of frequency assignments of satellite networks in certain space services and the other services to which certain bands are allocated"

  Recommendation 717 (Rev. WRC-95) - "Frequency sharing in frequency bands by the MSS and the FS, MS and other terrestrial radio services below 3 GHz"

JOINT WORKING PARTIES 8D & 9D

AGREEMENT ON FURTHER STUDIES ON FREQUENCY SHARING BETWEEN THE MSS AND THE FS BELOW 3 GHz

Study Items for which WP 8D is Lead

A1 Development of the standard computer program (SCP) for the coordination procedure (as outlined in Rec. ITU-R IS.1143)

A2 Development of the computer program for use to facilitate bilateral coordination of the non-GSO MSS with the FS. (The type of FS parameters to be used in bilateral coordination should be developed mainly by WP 9D)

Study Items for which WP 9D is Lead

B1 Consideration of the standard reference bandwidth for interference calculations, e.g. 1 MHz, 4 KHz or others depending on interference scenarios

B2 The aggregate interference of point-to-multipoint FS at low eirp to the MSS needs to studied for a large number of systems

B3 Consideration of combinations of non-GSO CDMA/FDMA and TDMA/FDMA systems for computation of the aggregate interference to victim FS receivers (see Rec. ITU-R IS.1143)

B4 Consideration of technical and operational matters in the phased transitional approach for bands shared between the MSS and the FS

FLOWCHART OF ITU-R RESOLUTIONS & RECOMMENDATIONS NEEDED FOR THE COORDINATION OF MSS & FS AT 2 GHz

Resolution Com 5-10

-Administrations responsible for MSS systems operating in the 2 Ghz bands should take into account the application of Resolution 46

Resolution 46 (Rev. WRC-95)

-Administrations are encouraged to use methodology described in Rec. ITU-R IS.1143 to effect coordination

Recommendation ITU-R IS.1143

1) Use system specific methodoly in Annex 1 to assess the need for coordination

2) Use methodology in Annex 3 to assess the level of interference into actual FS links

Annex 3 of Rec. ITU-R IS.1143

*-Cumulative distribution of C/(N+I) for analog and digital FS systems is evaluated using actual parameters, multipath model in **Rec. PN.530-5**, and the following interference criteria:*

*1) **ITU-R Rec. F.393-4** refers to total noise allowance for analog FS systems*

*2) **ITU-R.Rec. 697-1** refers to error performance objectives for digital FS systems in the local grade portion of the ISDN*

*3) **ITU-R Rec. 594-3** refers to error performance objectives for digital FS systems in the high grade portion of the ISDN*

JOINT WORKING PARTIES 8D & 9D

AGREEMENT ON FURTHER STUDIES ON FREQUENCY SHARING BETWEEN THE MSS AND THE FS BELOW 3 GHz

Study Items for which WP 8D is Lead

A1 Development of the standard computer program (SCP) for the coordination procedure (as outlined in Rec. ITU-R IS.1143)

A2 Development of the computer program for use to facilitate bilateral coordination of the non-GSO MSS with the FS. (The type of FS parameters to be used in bilateral coordination should be developed mainly by WP 9D)

Study Items for which WP 9D is Lead

B1 Consideration of the standard reference bandwidth for interference calculations, e.g. 1 MHz, 4 KHz or others depending on interference scenarios

B2 The aggregate interference of point-to-multipoint FS at low eirp to the MSS needs to studied for a large number of systems

B3 Consideration of combinations of non-GSO CDMA/FDMA and TDMA/FDMA systems for computation of the aggregate interference to victim FS receivers (see Rec. ITU-R IS.1143)

B4 Consideration of technical and operational matters in the phased transitional approach for bands shared between the MSS and the FS

6 Appointment of Rapporteurs

In order to accelerate the studies, the following Rapporteurs have been appointed:

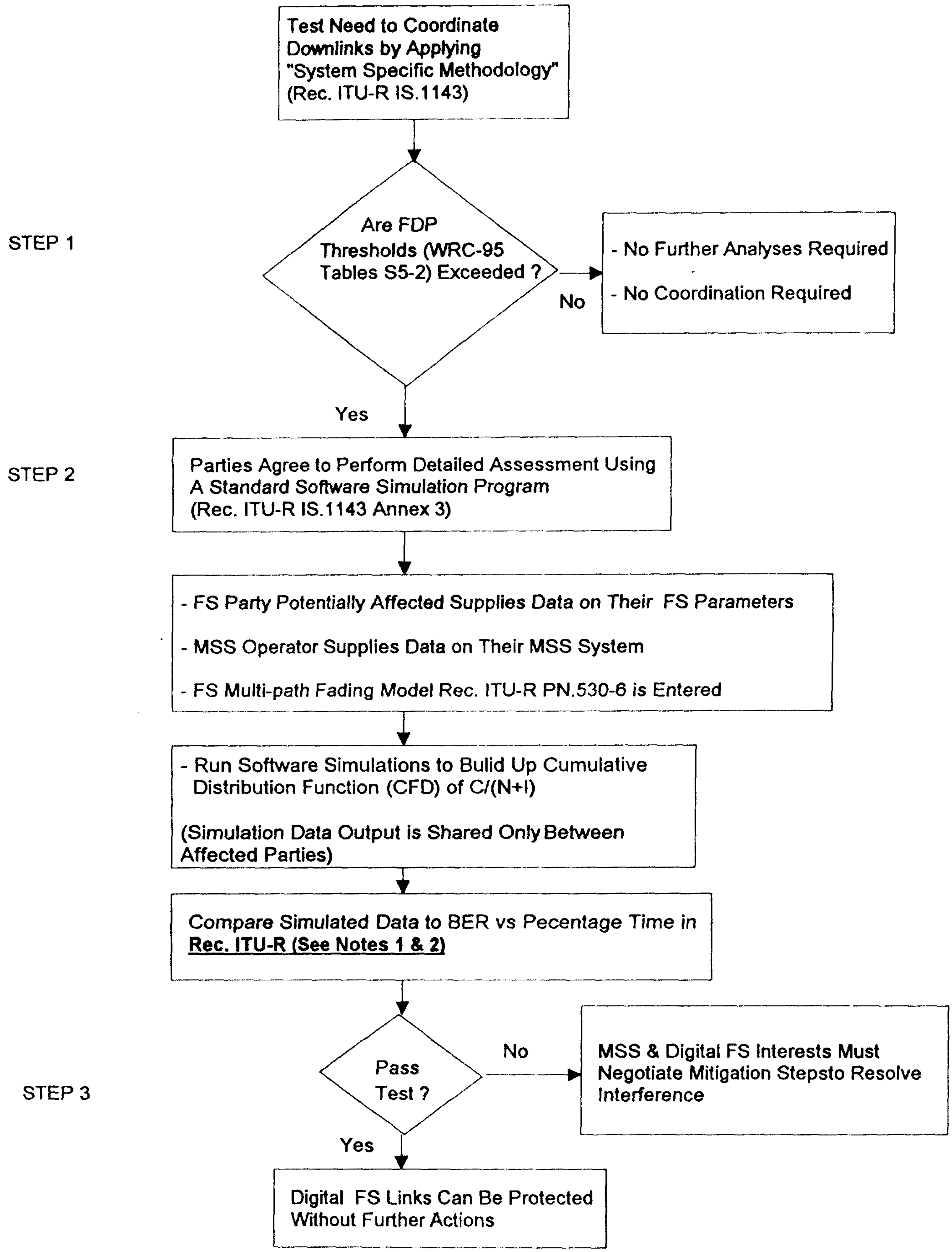
6.1 Working Party 8D

Principal Rapporteur:	Mr. T. Sullivan (United States)	Tel: +1 703 7166542 Fax: +1 703 7586111 Email:
Task A1 Rapporteur:	Mr. J. Mahe (France)	Tel: +33 1 44446768 Fax: +33 1 44444272 Email:
Task A2 Rapporteur:	Mr. J. Eneberg (United Kingdom)	Tel: +44 171 7281474 Fax: +44 171 7281174 Email:

6.2 Working Party 9D

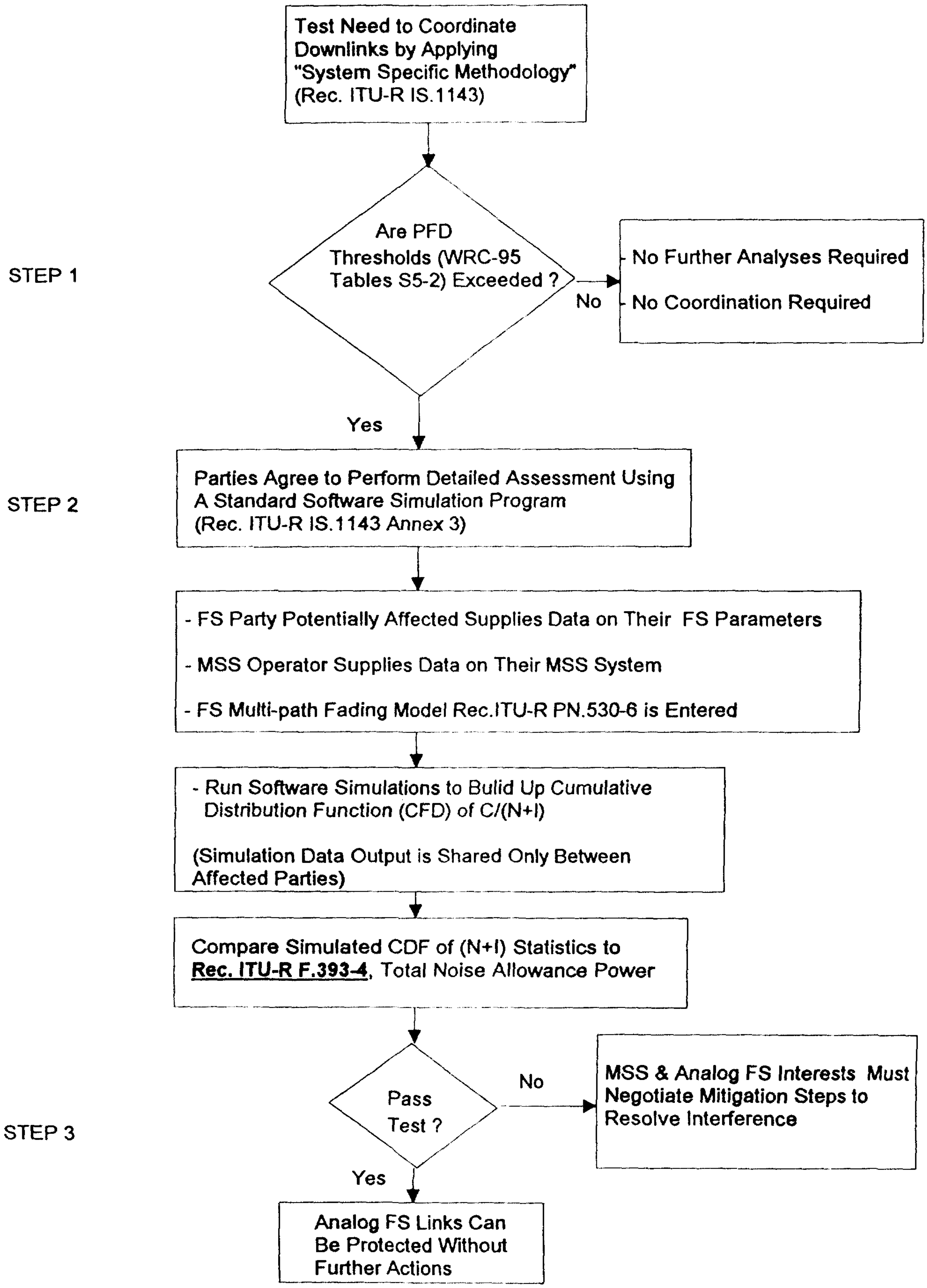
Principal Rapporteur:	Mr. G. Hurt (United States)	Tel: +1 202 482 1652 Fax: +1 202 482 4595 Email: ghurt@ntia.doc.gov
Task B1 Rapporteur:	Mr. Hashimoto (Japan)	Tel: +81 468 59 3200 Fax: +81 468 59 4254 Email: hasimoto@mhosun.wslab.ntt.jp
Task B2 Rapporteur:	Mr. A. Dixon (United Kingdom)	Tel: +44 171 211 0319 Fax: +44 171 211 0113 Email: alex.dixon@itu.ch
Task B3 Rapporteur:	(To be decided)	Tel: Fax: Email:
Task B4 Rapporteur:	Mr. G. Mitchel (Canada)	Tel: +1 613 9 904 792 Fax: +1 613 9 525 108 Email: mitchell.guy@ic.gc.ca
Task A1 and A2 Associate Rapporteur:	Mr. A. Latker (United States)	Tel: +1 202 7390 744 Fax: +1 202 8876 126 Email: alatker@nmaa.org

CHART B - ACTIONS TO COORDINATE MSS DOWNLINKS INTO EXISTING <u>DIGITAL</u> FS RECEIVE STATIONS



Notes: 1) **Rec. ITU-R F.697-1** for digital FS system in the local grade portion of ISDN
2) **Rec. ITU-R F.634-2** or **F.594-3** for digital system in the high grade portion of ISDN

CHART C - ACTIONS TO COORDINATE MSS DOWNLINKS INTO EXISTING ANALOG FS RECEIVE STATIONS



TECHNICAL NOTE

ITU Recommendation 530

Introduction

Recommendation ITU-R PN 530 specifies a fade model that can be used for the Fixed Service. This model includes three parts

the standard equation, for deep fades that occur for low percentages of time

1. extrapolation equation, for fades between zero and those used in the standard equation

2. enhancement, where signal increases in strength and fade is effectively negative

The cross-over between sections 2 and 3 is fixed at 63.208 %, while the cross-over between sections 1 and 2 depends on link characteristics and could be at either a fade depth of 25 or 35 dB.

Recommendation 530 equations give the cumulative distribution function for fade not exceeded for a given percentage of time. Inversion of the cumulative distribution function (cdf) combined with uniform random sampling of the inverse function will produce a fade distribution as desired. The inversion is performed numerically using a binary chop algorithm.

An example distribution is shown below produced by Visualyse™, using $K = 10^{-6}$.

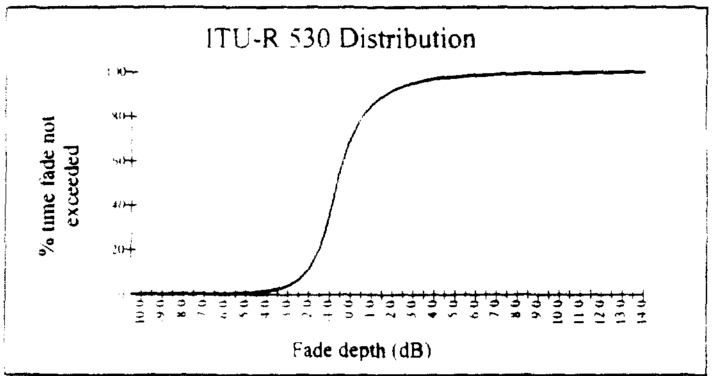


Figure 1. ITU-R 530 Fade Distribution

The inputs to the algorithm are:

- percentage of time PC, converted to a probability p
- height of station 1 h_1 in m
- height of station 2 h_2 in m
- frequency f in GHz
- distance between stations D in km
- path parameter, K

The first parameter to calculate is the modified path parameter K_1:

$$K_1 = KD_{km}^{3.6} f_{GHz}^{0.89} \left(1 + \frac{abs(h_1 - h_2)}{D}\right)^{-1.4}$$

If the percentage is less than 63.208 % then the fade algorithm is used otherwise the enhancement algorithm is used. The algorithms do a binary chop between maximum and minimum enhancements, defined to be:

maximum fade / enhancement: +50 dB

minimum fade / enhancement: -50 dB

Each calculation to calculate p(A) given A is described in the following sections. This is used to narrow down on the fade A for the specified percentage. The binary chop terminates when one of the following occurs:

- the number of binary chops exceeds 20
- the difference between fade depths is less than 0.01 dB

Fade Distribution

The algorithm to calculate the probability of a fade p(A) given a fade A and K_1 is:

if the fade is greater than 35 dB then:

p = p(LF) using K_1

otherwise:

calculate q_t from 35 dB and K_1

if q_t is positive then:

if A is greater than 25, then:

p = p(LF) using K_1

otherwise:

calculate q_t from 25 dB and K_1

p = p(SF) using q_t

otherwise:

$p = p(SF)$ using q_t

The following equation is used to calculate the probability of a large fade:

$$p(LF) = K_1 \frac{10^{-A/10}}{100}$$

The following equation is used to calculate the probability of a small fade:

$$p(SF) = 2 + \left[1 + 0.3 * 10^{-A/20}\right]$$
$$\left[q_t + 4.3\left(10^{-A/20} + \frac{A}{800}\right)\right]10^{-0.016A}$$

The following equations are used to calculate q_t from A and K_1:

p = probability of large fade (A, K_1)

$$q_a = \frac{-20\log_{10}\left[-\log(1-p)\right]}{A}$$

$$q_t = \frac{q_a - 2}{\left[\left(1 + 0.3 * 10^{-A/20}\right)10^{-0.016A}\right]} - 4.3 * 10^{-A/20} + \frac{A}{800}$$

Enhancement Distribution

The enhancement distribution is split into large and small enhancements defined as greater or less than 10dB. A key factor is the parameter K_2, which is the probability of a 10dB *fade* using the K_1 parameter. For each test enhancement over 10dB, the probability is calculated using p(LE), for each test enhancement under 10 dB, the probability is calculated using p(SE). These two algorithms are described below.

The probability of a large enhancement is calculated using:

$$p(LE) = \frac{100 - 10^{\frac{-1.7 + 0.2K_2 - A}{3.5}}}{100}$$

The probability of a small enhancement is calculated using:

Calculate probability of enhancement of 10dB, p_{10} = p(LE) using A=10 and K_2.

Then:

$$Q_s = 2.05\left\{-2\log_{10}\left[-\log\left(1 - \frac{1 - p_{10}}{0.5821}\right)\right]\right\} - 20.3$$

$$Q_e = 8 + \left[1 + 0.3 * 10^{-A/20}\right]\left[Q_s + 12 * \left(10^{-A/20} + \tfrac{A}{800}\right)\right]10^{-0.7A/20}$$

So:

$$p(SE) = 1 - \left[1 - e^{-10^{-Q_e A/20}}\right] * 0.5821$$

K Factor

The geo-climatic factor K is derived from empirical formulas including the mid-path latitude and longitude and the percentage time that the gradient of the refractive index of the atmosphere falls below -100units/km (pL). Thus a dependence on the bulk properties of the atmosphere is built into the fade model.

pL can be obtained from the contour maps given in Figures 7-10 of Recommendation ITU-R PN.453. A value is given for the four seasonally representative months Februaury, May, August and November. The highest value of pL should be chosen.

A value for K should then be derived from the following table:

Path type	**K**
overland non-mountainous	$10^{-6.5-Clat-Clong} p_L^{1.5}$
overland mountainous	$10^{-7.1-Clat-Clong} p_L^{1.5}$
over medium bodies of water	$10^{-5.9-Clat-Clong} p_L^{1.5}$
over large bodies of water	$10^{-5.5-Clat-Clong} p_L^{1.5}$

The coefficients Clat at latitude ς are given by:

Clat = 0	for $\lvert\varsigma\rvert \le 53$
Clat = $-5.3 + \varsigma/10$	for $53 < \lvert\varsigma\rvert < 60$
Clat = 0.7	for $\lvert\varsigma\rvert \ge 60$

Clong is defined in the Rec by the following vacuous set of equations:

Clong = 0.3	for longitudes of Europe and Africa
Clong = -0.3	for longiutdes of North and South America
Clong = 0	all other longitudes

Guidance on the selection of a path type is given in the notes of Recommendation ITU-R PN530.

TECHNICAL NOTE

Visualyse™ Gain Patterns

Introduction

This section describes the masks that are used for the equation Beam Types in Visualyse. Note that offaxis gains are relative to gain at boresight, and so are usually negative. All Beam Types have the following defined:

- peak gain G_{max}
- half power beamwidth in direction of interest θ_{3dB}

Other parameters can also be available depending upon situation. All angles are in degrees except where specified. A useful parameter is the D/λ, ratio of dish size to wavelength. This is calculated using:

$$\frac{D}{\lambda} = 10^{(G_{max} - 7.7)/20}$$

Where useful, a plot of the gain pattern has been producing, using the following parameters:

G_{max} = 35 dBi

θ_{3dB} = 5°

The graphs were produced by Visualyse using the linear beam type for offaxis angle. Note that this gives negative values rather than positive, so the offaxis angle ranges from -90 to 0 rather than +90 to 0.

Parabolic

This pattern is parabolic with floor defined. The equation is:

$$G_{rel} = \max\left[G_{floor}, -12\left(\frac{\theta}{\theta_{3dB}}\right)^2\right]$$

The G_{floor} is input by the user. A typical value is -25 dB.

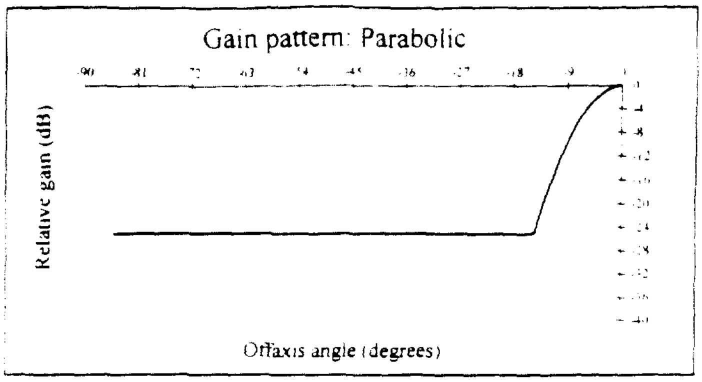


Figure 1. Parabolic Gain Pattern

Omni Directional

This gives the same value in all directions. It is set at 0 dB.

ITU-R 699-II

This is used for FS systems. The equations are:

Calculate:

$$G_1 = 2 + 15\log_{10}\left(\frac{D}{\lambda}\right)$$

$$\phi_m = \frac{20}{D/\lambda}\sqrt{G_{\max} - G_1}$$

The in the case where $D/\lambda < 100$:

calculate:

$$\phi_r = \frac{100}{D/\lambda}$$

then:

when $\theta < \phi_m$ $\quad G_{abs} = G_{\max} - 2.5 * 10^{-3}\left(\frac{D}{\lambda}\right)^2 \theta^2$

when $\theta < \phi_r$ $\quad G_{abs} = G_1$

when $\theta < 48°$ $\quad G_{abs} = 52 - 10\log_{10}\left(\frac{D}{\lambda}\right) - 25\log\theta$

otherwise: $\quad G_{abs} = 10 - 10\log_{10}\left(\frac{D}{\lambda}\right)$

Then in the case where $D/\lambda \geq 100$:

calculate:

$$\phi_r = 15.85 * \left(\frac{D}{\lambda}\right)^{-0.6}$$

then:

when $\theta < \phi_m$ $\quad G_{abs} = G_{max} - 2.5 * 10^{-3} \left(\frac{D}{\lambda}\right)^2 \theta^2$

when $\theta < \phi_r$ $\quad G_{abs} = G_1$

when $\theta < 48°$ $\quad G_{abs} = 32 - 25\log_{10}\theta$

otherwise: $\quad G_{abs} = -10$

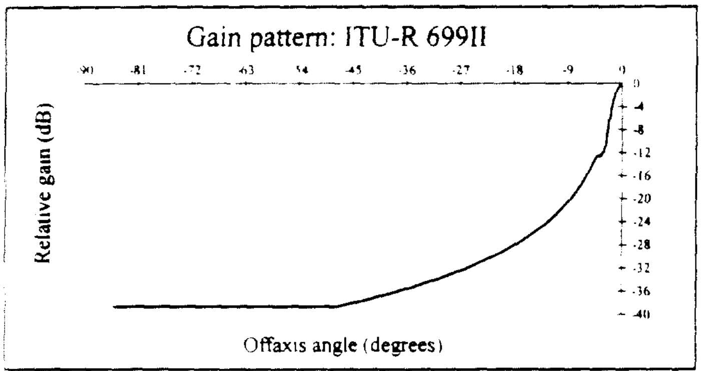


Figure 2. ITU-R 699II Gain Pattern

Note that ITU-R 699II and ITU-R 699IIR makes various assumptions about the beam size, and that the half power beamwidth size is not used directly but is implied through the D/λ.

ITU-R 699-IIR

This equation is the revised version with lower sidelobes. Where multiple offaxis contributions to interference are seen, it is important not to be too pessimistic in the modelling of antenna sidelobes. This equation is the revised version of 699ii, which, when integrated over a sphere, gives a more physically realisable result, i.e., it does not transmit more power at the antenna output than receives at the antenna input.

Calculate:

$$G_1 = 2 + 15\log_{10}\left(\frac{D}{\lambda}\right)$$

$$\phi_m = \frac{20}{\frac{D}{\lambda}}\sqrt{G_{max} - G_1}$$

The in the case where D/λ < 100:

calculate:

$$\phi_r = \frac{75.86}{\frac{D}{\lambda}}$$

then:

when $\theta < \phi_m$ $\quad G_{abs} = G_{\max} - 2.5 * 10^{-3}\left(\frac{D}{\lambda}\right)^2 \theta^2$

when $\theta < \phi_r$ $\quad G_{abs} = G_1$

when $\theta < 48°$ $\quad G_{abs} = 49 - 10\log_{10}\left(\frac{D}{\lambda}\right) - 25\log\theta$

otherwise: $\quad G_{abs} = 7 - 10\log_{10}\left(\frac{D}{\lambda}\right)$

Then in the case where $D/\lambda \geq 100$:

calculate:

$$\phi_r = 15.85 * \left(\frac{D}{\lambda}\right)^{-0.6}$$

then:

when $\theta < \phi_m$ $\quad G_{abs} = G_{\max} - 2.5 * 10^{-3}\left(\frac{D}{\lambda}\right)^2 \theta^2$

when $\theta < \phi_r$ $\quad G_{abs} = G_1$

when $\theta < 48°$ $\quad G_{abs} = 32 - 25\log_{10}\theta$

otherwise: $\quad G_{abs} = -10$

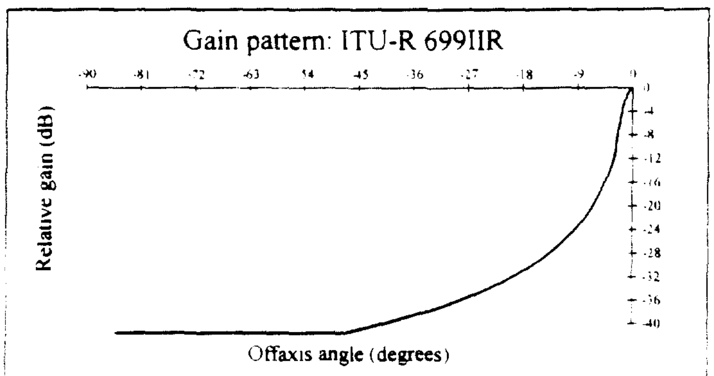


Figure 3. ITU-R 699IIR Gain Pattern

ITU-R 558

This pattern is for circular space spots. The Equations depend upon one of three types. which defines the first side lobe level. L_s, as being one of -20, -25, -30 dB. The value of Ls determines the start and end of the side lobe, defined by parameters a and b. The patterns are defined as:

The values of Ls, a, b, depend on the type, which can be one of I, II, or III, as shown in the table below:

Type	L_s	a	b
I	-20	2.58	6.32
II	-25	2.88	6.32
II	-30	3.16	6.32

The equations are then:

Using:

$$\psi = \frac{\theta}{\left(\frac{\theta_{3dB}}{2}\right)}$$

Then:

if $\psi \le a$:

then $G_{abs} = G_{max} - 3\psi^2$

if $a < \psi \le b$:

then $G_{abs} = G_{max} + L_s$

if $b < \psi$:

then $G_{abs} = \max\left[0, G_{max} + L_s + 20 - 25\log\psi\right]$

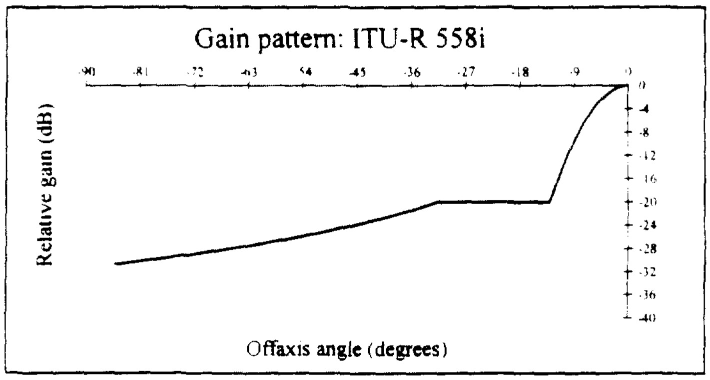


Figure 4. ITU-R 558i Gain Pattern

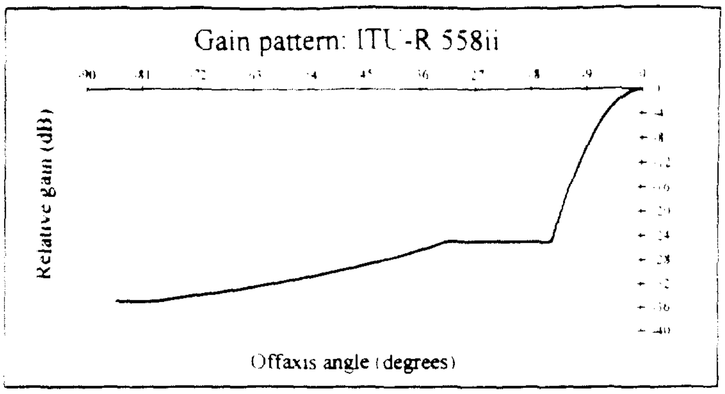


Figure 5. ITU-R 558ii Gain Pattern

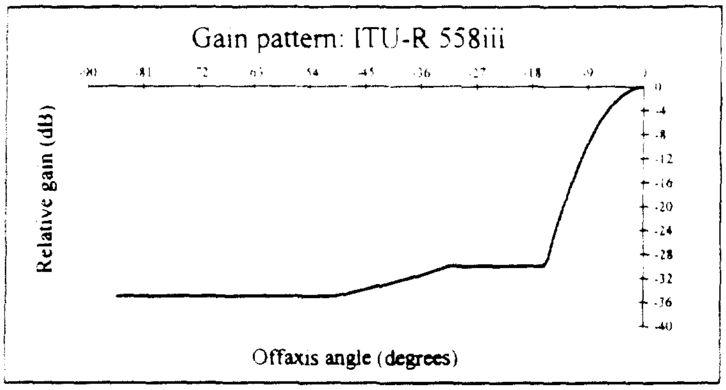


Figure 6. ITU-R 558iii Gain Pattern

TVRO

The equations for Radio Regulations TVRO dishes are:

when $\theta < 0.25\theta_{3dB}$

$$G_{rel} = 0$$

else when $\theta < 0.707\theta_{3dB}$

$$G_{rel} = -12\left(\frac{\theta}{\theta_{3dB}}\right)^2$$

else when $\theta < 1.26\theta_{3dB}$

$$G_{rel} = -\left(9 + 20\log_{10}\left(\frac{\theta}{\theta_{3dB}}\right)\right)$$

else when $\theta < 9.55\theta_{3dB}$

$$G_{rel} = -\left(8.5 + 20\log_{10}\left(\frac{\theta}{\theta_{3dB}}\right)\right)$$

otherwise:

$G_{rel} = -33$

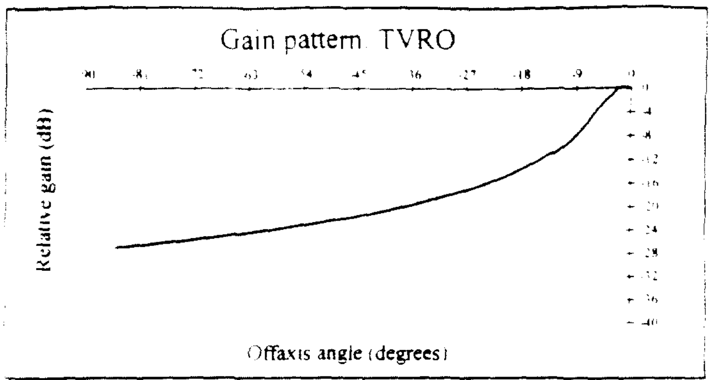


Figure 7. TVRO Gain Pattern

SMATV

The equations for Radio Regulations SMATV dishes are:

when $\theta < 0.25\theta_{3dB}$

$G_{rel} = 0$

else when $\theta < 0.86\theta_{3dB}$

$$G_{rel} = -12\left(\frac{\theta}{\theta_{3dB}}\right)^2$$

otherwise:

$$G_{rel} = -\left(10.5 + 25\log_{10}\left(\frac{\theta}{\theta_{3dB}}\right)\right)$$

Note that G_{rel} can not be less than $-G_{max}$.

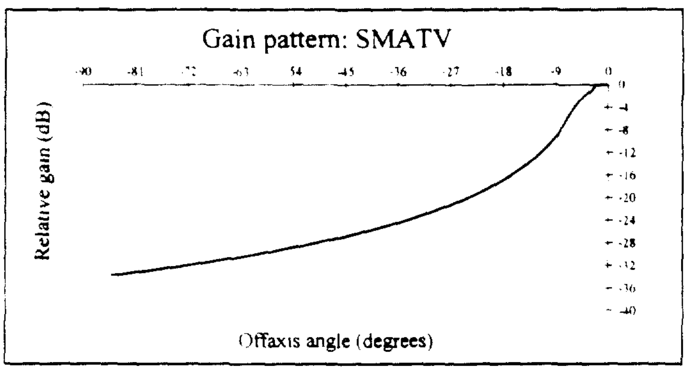


Figure 8. SMATV Gain Pattern

Appendix 30 Space

The equations for Appendix 30 Space dishes are:

when $\theta < 1.45\theta_{3dB}$

$$G_{rel} = -12\left(\frac{\theta}{\theta_{3dB}}\right)^2$$

otherwise:

$$G_{rel} = -\left(22 + 20\log_{10}\left(\frac{\theta}{\theta_{3dB}}\right)\right)$$

Note that G_{rel} can not be less than $-G_{max}$.

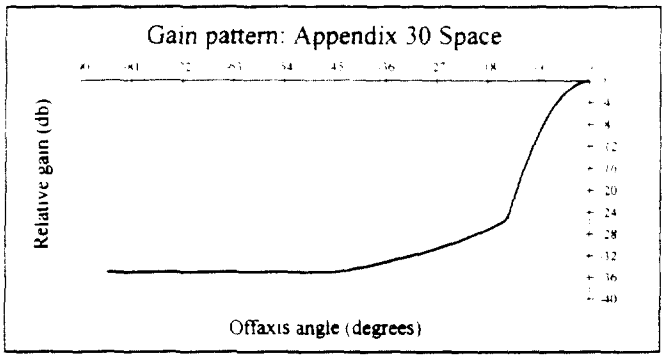


Figure 9. Appendix 30 Space Gain Pattern

Appendix 30 Space Fast Roll-Off

The equations for Appendix 30 Space Fast Roll Off dishes are:

Calculate:

$$\phi = 0.5\left(1 - \frac{0.8}{\theta_{3dB}}\right)$$

Then:

when $\theta < 0.5\theta_{3dB}$:

$$G_{rel} = -12\left(\frac{\theta}{\theta_{3dB}}\right)^2$$

else when $\theta < 1.16 + \phi\theta_{3dB}$:

$$G_{rel} = -18.75(\theta - \phi\theta_{3dB})^2$$

else when $\theta < 1.45\theta_{3dB}$:

$$G_{rel} = -25.23$$

otherwise:

$$G_{rel} = -\left(22 + 20\log_{10}\left(\frac{\theta}{\theta_{3dB}}\right)\right)$$

Note that G_{rel} can not be less than $-G_{max}$.

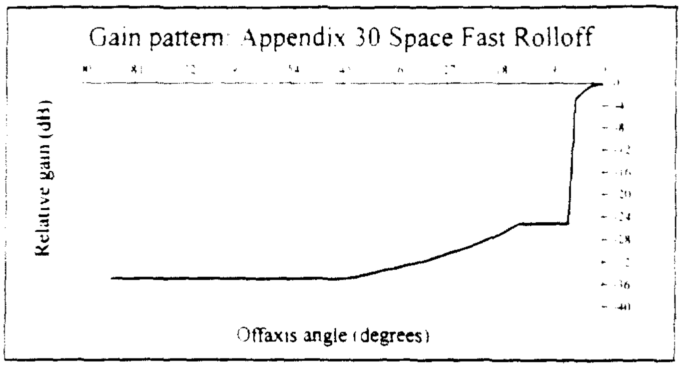


Figure 10. Appendix 30 Space Fast Rolloff Gain Pattern

Linear

This algorithm is used so that the offaxis angle can be determined from the offaxis gain. The equation is:

$$G_{rel} = -\theta$$